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## **THE LABORATORY'S FOOTPRINT: OUR ENVIRONMENTAL IMPACTS**

by

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**Risk Reduction and Environmental Stewardship  
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The Laboratory's Footprint: Our Environmental Impacts

**Executive Summary**

An Ecological Footprint has been calculated for the Los Alamos National Laboratory. The footprint is a tool designed to quantify the environmental impact of an organization. Developing the footprint of the Laboratory gauges the extent of the environmental impact from routine Laboratory activities. The footprint identifies the contributors to our overall environmental impact, and helps to prioritize preventative actions.

The concept of the footprint is based on determining the equivalent land area necessary to support resource consumption and waste generation by an organization. Converting resource consumption and waste generation to land area is principally accomplished by calculating carbon dioxide emissions associated with these activities, and the amount of land needed to reabsorb this carbon dioxide. The footprint calculations demonstrate the impact of using nonrenewable fossil fuel resources as well as the necessity of limiting human contributions to the greenhouse effect.

The Laboratory's total footprint was calculated as 245,000 hectare-years (945 square miles) for FY01. This equivalent land area represents 22 times the actual Laboratory site. Footprint calculations indicate that the largest contributors to environmental impacts come from transportation and energy activities. To a certain extent, these impacts are due to mission goals and to working in a location chosen 50 years ago precisely for its remoteness. It is unlikely that similar institutions, such as Argonne, Brookhaven, or Lawrence Livermore National Laboratories, have as large a transportation component given their locations adjacent to major metropolitan areas. These locations have more access to public transportation, and distances traveled between home and work are reduced. Our remote location also requires longer transport distances for materials brought to the Laboratory than would be the case if we were closer to an industrial center. While a number of factors affecting the size of our environmental footprint are beyond our control, there are still a number of actions we can take to reduce the Laboratory's environmental impact without impeding mission goals or greatly increasing costs for the Laboratory.

The concept of the footprint is an approximation of impact; it is admittedly imprecise in its measurement. Nonetheless, it is a valuable tool to understanding environmental impact patterns, especially over time. It can be used effectively to prioritize positive alternative actions and to clearly illustrate future environmental focus needs.

**What is a Footprint?**

Every person has an impact on the environment. Whether you are a hermit eating only nuts and berries in the Jemez Mountains or the manager of a coal operating plant in Four Corners, New Mexico, you use the earth for sustenance and for the absorption of wastes.

People consume the products and services of nature as an everyday, natural part of life. This is not a problem, as long as the human load does not exceed the ecological capacity of the Earth. But how do we determine this capacity, and whether the Earth can sustain our current level of activities? The Ecological Footprint is a concept designed to answer these questions. It is an analysis tool that estimates people's impact on their environment. It measures the equivalent land area necessary to sustain current levels of resource consumption and waste discharge by a given population. The tool can be used on any scale; it can be measured globally, nationally, regionally, individually, or in our case, at an organizational level.

Presently, the Laboratory is focused on the local environmental impacts of institutional activities. This is demonstrated by compliance with state and federal regulations of site pollution and resource conservation. Discharges into the air, water, and ground are carefully monitored and minimized. However, the larger ramifications of all activities are, for the large part, yet to be understood or accounted for in current monitoring. Many of the impacts from the Laboratory are located far outside the realm of our monitoring. In this time of growing globalization, the economic trade lines have become a tangled web. A raw material may pass through many countries before arriving at our doorstep as a finished product. The areas that absorb the impacts of consumption and production have become enmeshed in the network of the global community. Cafeteria food may be grown on farms from around the country, and computers may be manufactured in another country and shipped to the Laboratory from overseas. Footprint analysis is a tool that finally enables us to measure our combined environmental impacts around the world, from where we first draw upon resources to where we ultimately deposit our wastes.

The concept behind the footprint analysis is that most of the resources and waste flows can be converted into an equivalent area of biologically productive land or water. Biologically productive land is a combination of arable, pasture, and forested land. It is land we use to grow our food or provide timber products. The footprint calculates the land or sea area necessary to produce and absorb a material or energy, along with the area necessary to absorb the corresponding greenhouse gas emissions. For the most part, the concept of the ecological footprint is dominated by global warming. The global warming potential is based on the effects on the atmosphere over the estimated lifetime of greenhouse gases. For the purposes of this calculation, the greenhouse gases are limited to a measurement of carbon dioxide (CO<sub>2</sub>).

According to the University Corporation for Atmospheric Research (UCAR), CO<sub>2</sub> concentrations have been steadily increasing since the 1800s. They estimate that some 3 gigatons (3 billion metric tons) of CO<sub>2</sub> are being added to the atmosphere every year. CO<sub>2</sub> is considered the most important human-influenced greenhouse gas. It is produced primarily from the burning of fossil fuels (motorized vehicles, electric power plants, and homes heated with gas or oil) and the burning and clearing of forested land for agricultural purposes. Data from the National Center for Atmospheric Research shows that CO<sub>2</sub> accounts for about half of the human contributed greenhouse gases, of which the USA produces 21%. This is illustrated in Figure 1 below.

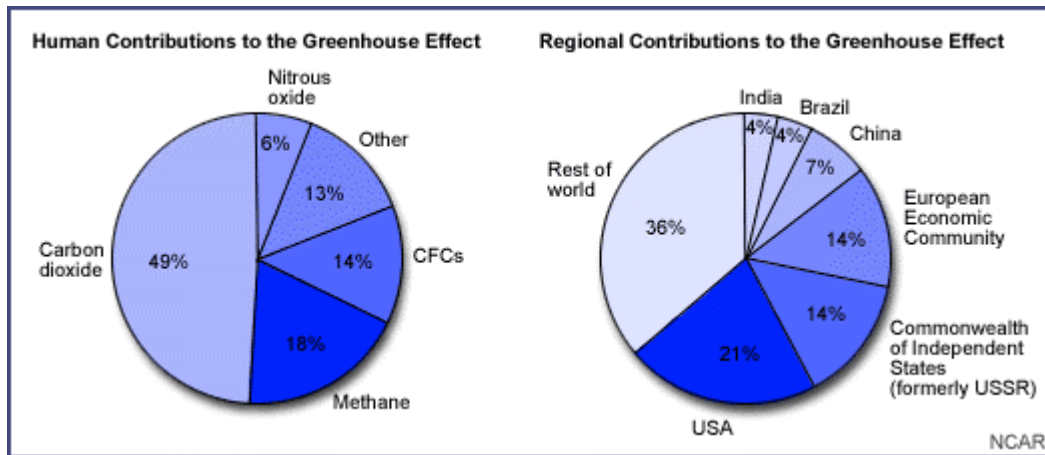


Figure 1. Contributions to the Greenhouse Effect

CO<sub>2</sub> is a powerful greenhouse gas that absorbs and maintains heat. Therefore, scientists believe that the earth's temperature should go up as CO<sub>2</sub> concentrations increase. Climatologists have been collecting weather data from around the world. UCAR reports that there has been a steady but small increase in global average temperatures over the last few decades. Six of the last ten were the hottest years on record. Figure 2 shows data taken from NOAA and UCAR, demonstrating the increasing trend in global average temperature for the past century.

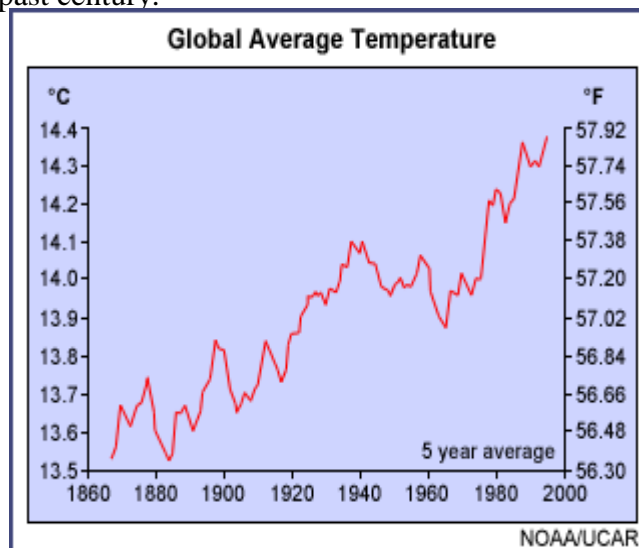


Figure 2. Global Average Temperature Trend

Due to the importance of the effects of CO<sub>2</sub>, the footprint analysis focuses a great deal on the production and absorption of this greenhouse gas. To calculate the CO<sub>2</sub> contribution to the footprint, materials and wastes of an organization are therefore usually converted first into the amount of carbon dioxide released from the embodied energy and then into the equivalent land area needed for the CO<sub>2</sub> absorption. Land area is measured in hectares, which are 2.5 times the size of acres. This area equals roughly the size of two and a half football fields. The total area of the Laboratory site is about 11,200 hectares (or

43 square miles). The time scale for the footprint is measured in years. The footprint is therefore a measure of the amount of hectares needed for one equivalent year. This standard way of reporting a footprint uses the unit of hectare-years (ha-years). The calculation methodology converts the measurements of land so that the production or reabsorption takes place in the time span of a single year. For the ease of comprehension and comparison to the actual Laboratory site area, the unit of hectares will be used in this report.

## **The Size of Our Feet**

Environmental consequences of our decisions are not built into the prices we pay for executing these decisions. When we run experiments that use large amounts of electricity, we do not pay extra to clean up the carbon dioxide produced by the coal plant generating that electricity. When we do not recycle our paper, we do not pay extra to compensate for the loss of a carbon sink, loss of habitat, and increase in risk of erosion when virgin forest must be cut down. When we supply coffee for the Laboratory, we do not pay extra to restore the foreign soil degraded by chemicals or inferior farming practices in order to grow that coffee. If we deplete our water resources, we do not pay extra to mitigate the loss of the many fish and animals living within the watershed that depend on water for survival.

Consideration of the regional and global impacts of resource use in the past has been difficult to initiate because it has been difficult to quantify. Footprint analysis brings together environmental measurements under a universal metric. This metric identifies the environmental consequences of the choices the Laboratory makes and measures the cumulative effect of those choices in a single, area-equivalent number to which everyone can relate. Once the total effect, or footprint, is known, we can begin to delve deeper into understanding the relative impacts of different aspects of our operations. As with other organizational metrics, we can benchmark our environmental performance with similar institutions. In this way, we can measure our relative progress towards a sustainable future. We can take responsibility for all our environmental impacts and reduce the size of our feet.

## **Methodology**

The global environmental impact is the sum of all human impacts combined. Just like the globe, the Laboratory's environmental issues are a composite of the many division, group, and employee impacts. In order to be successful in driving the environmental impact of the Laboratory down, the key components must be acknowledged, measured and addressed. The first step in analyzing the total environmental impact of the Laboratory is to recognize its sources. We can then quantify the impact by category and begin to prioritize our focus for environmental performance improvement.

The contributing factors to the Laboratory's footprint are broken down into the resources brought into the Laboratory and the wastes generated and disposed of by the Laboratory. There are five main categories for resource use: transportation, energy, purchased

materials, land, and water. These are further broken down into subcategories. The subcategories of waste generation are: sanitary waste, transuranic waste or TRU-waste (contains >100 nCi of alpha-emitting TRU isotopes per gram of waste), mixed transuranic waste (contains TRU waste and RCRA-hazardous materials), low-level waste (radioactive with TRU waste elements <100 nCi/g of waste), mixed low-level waste (contains low-level waste and RCRA-hazardous materials), hazardous waste, and mixed toxic substance control act waste.

### *Transportation*

The Los Alamos National Laboratory was established in the mountains of New Mexico as a top secret, temporary laboratory during World War II. At that time, the location of Los Alamos was ideal; its isolation and remoteness allowed scientists to accomplish their mission of developing nuclear weapons far from any prying eyes. Over the years, the Laboratory has expanded its mission to include developing the best science and technology to make the world a better and safer place. The Laboratory has become a long-term national leader in science and technology. Today, the once ideal location now serves to increase the Laboratory's environmental impact as resources and employees have to travel large distances to and from the site. Altogether, it takes about 100,700 hectares of land (or 390 square miles) a year to support the transportation requirements of life at the Laboratory. This amount of land is about 9 times the actual size of the Laboratory site.

The transportation component of the Laboratory's footprint is comprised of freight transport, commuting to the site, Laboratory sponsored air travel, and vehicle travel on site. The breakdown of these categories can be seen in Figure 3.

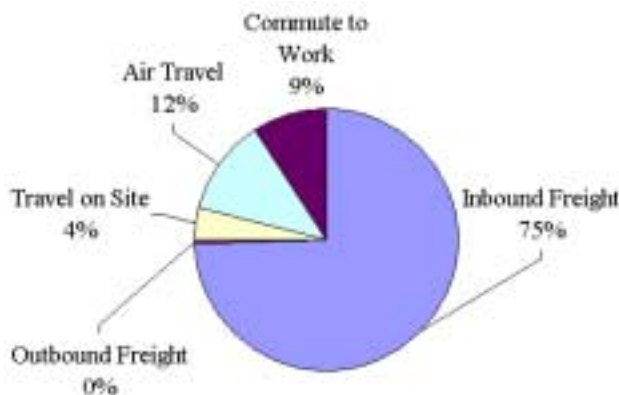


Figure 3. Percentages of Types of Transportation Used by the Laboratory for FY01

Freight transport for the Laboratory includes all shipments entering and leaving the site. The calculations for this subcategory can be seen in Table 1. Inbound freight is shipped to the Laboratory in three main ways: air carriers, local carriers, and large freight carriers. All inbound shipment activity represents an estimated 75,000 hectares. The largest portion of this footprint is from large freight, which is shipped from both national and

international locations. Outbound freight activity accounts for about one thousand metric tonnes of material, mostly in the form of electronics and computers sent out for repair. The footprint from outbound freight transport is 400 hectares. The total freight component footprint is equal to 75,400 hectares (290 square miles) for FY01. This is 6.5 times the actual size of the Laboratory site.

Table 1. Calculations for Freight Component of Transportation Footprint for FY01

<b>INBOUND</b>				
apx. inbound=	381,000tons			<b>346,000tonnes</b>
Type of Shipment	Percent Weight	Weight (1000 tonnes)	Est. Avg. Distance (km)	1000 Tonne-km
Air Carriers	20%	69	1,600	110,000
Local Carriers	30%	104	80	8,300
Large Freight	50%	173	3,200	556,000
<b>TOTALS</b>		<b>346</b>		<b>676,000</b>
<b>Footprint (ha years)</b>				<b>75,000</b>
<b>OUTBOUND</b>				
apx. outbound=	2,600,000lbs			<b>1,200tonnes</b>
Type of Shipment	Percent Weight	Weight (1000 tonnes)	Est. Avg. Distance (km)	1000 Tonne-km
Air Carriers	60%	0.7	1,600	1,100
Large Freight	30%	0.35	1,600	560
Heavy Weight	10%	0.12	1,600	188
<b>TOTALS</b>		<b>1.2</b>		<b>1,900</b>
<b>Footprint (ha years)</b>				<b>400</b>

In addition to materials being transported to the Laboratory, employees also come from great distances to reach work. Most employees commute an average of 20 miles to work. However, 40% of the workforce travels a round-trip distance of 40 to 70 miles. This commuting adds up to a total of 157 million kilometers (98 million miles) each year. The footprint from this subcategory is 12,000 hectares (46 square miles), slightly larger than the actual size of the Laboratory site. Table 2 shows a more detailed breakdown of commuting to work.

Table 2. Footprint of Commute to Work Category of Transportation Footprint for FY01

<b>Total Employees by County of Residence as of 10/3/01</b> (estimate based on Regular Employees ratios)						
	# Employees	County	Percent	Avg. Miles Traveled	1000 Miles per Year	1000 KM per Year
	5,576	Los Alamos	54%	20	25,000	40,000
	1,830	Rio Arriba	18%	40	16,000	26,000
	2,264	Santa Fe	22%	70	36,000	57,000
	337	Sandoval	3%	160	12,000	19,000
	157	Bernalillo	2%	190	6,700	11,000
	58	Taos	1%	80	1,000	1,700
	81	Other	1%	50	915	1,500
<b>TOTAL</b>	<b>10304</b>		<b>100%</b>		<b>98,000</b>	<b>157,000</b>
Percent Employee Carpooling=						15%
<b>COMMUTE TO WORK FOOTPRINT (ha years) =</b>						<b>12,000</b>

Driving doesn't end once employees reach the site. The Laboratory is 43 square miles in area. This means that employees must often drive to get to meetings with other group or division members. In FY01, there were 10,000 employees working at the Laboratory, contributing to the footprint for on site vehicle travel. It is estimated that an employee travels an average of 10 miles per day for 225 workdays per year. This distance equals 23 million miles, or 900 trips around the world. On site traveling leaves a footprint the size of almost 4,000 hectares (15 square miles) for FY01, or about 35% of the size of the Laboratory.

In FY01, the Laboratory spent \$10.6 million on air travel. Laboratory employees traveled an estimated 131 million kilometers (81.6 million miles) to destinations around the world. The distance represents over 3000 trips around the world. The number of air kilometers is based on a conservative estimate of the average revenue yield per passenger seat mile for FY01 for the four largest airline carriers used by the Laboratory. All this traveling produced about 14 million kilograms of CO<sub>2</sub>. This air travel yields an annual footprint of 9000 hectares (35 square miles). This means that it takes an equivalent land area 80% of the actual size of the Laboratory site for air travel alone.

### *Energy*

The Laboratory is an institution that functions on the cutting edge of science and technology. There is ongoing research in all disciplines, from neutron physics to high explosives chemistry to ecosystem computer modeling. Often, this research and the support systems for their execution can be quite energy intensive. For example, a typical fume hood in a chemistry laboratory can use as much electricity as can an entire household. Other major energy consumers include the computer support centers and the Los Alamos Neutron Science Center (LANSCE). LANSCE is defined by its high current 800-MeV linear accelerator and its capability of delivering to a variety of targets for different scientific purposes.

Most of the energy consumed at the Laboratory is in the form of natural gas for heating and electricity. Electricity at the Laboratory is produced using natural gas, coal, and hydroelectric power. Currently, only the electricity supply to LANSCE is monitored on a constant basis. As shown in Figure 4, natural gas for heating accounts for about half of the energy supply, coal accounts for a little over 30%, and hydroelectric power supplies a quarter of the energy supply to the Laboratory.

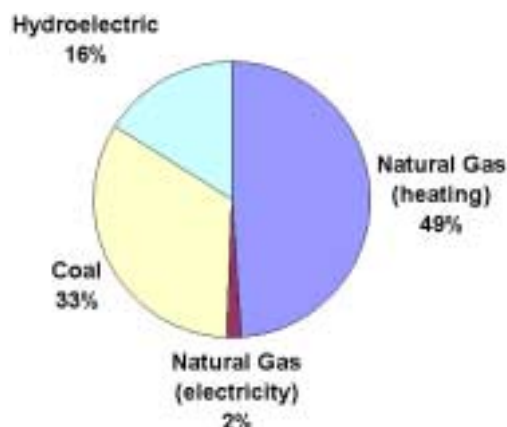


Figure 4. Percentages of Types of Energy Supplied to the Laboratory for FY01 (based on GWH)

Figure 5 shows the proportion of the total energy footprint for each category. As is shown, coal accounts for 60% of the energy footprint for the Laboratory while natural gas for heating accounts for a quarter of the footprint. This demonstrates the advantage to using cleaner energy sources. Natural gas is a cleaner burning source of energy, producing less CO<sub>2</sub> emissions. This means that it uses less equivalent land to support natural gas use. Therefore, although natural gas supplies half of the energy, it represents only a quarter of the footprint. Coal power uses 160 hectares to produce one GWH of energy. Coal power is therefore the largest component of the energy footprint.

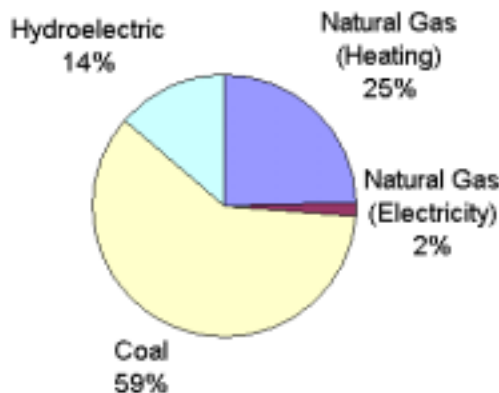


Figure 5. Percentage of Energy Footprint for Each Type of Energy Source for the Laboratory for FY01 (based on ha-yrs)

Supporting the energy needs of the Laboratory requires about 66,000 hectares (255 square miles) of land each year. This footprint component accounts for an area 6 times the actual size of the Laboratory site. This footprint can be shown as a per capita energy footprint for Laboratory employees and compared to the per capita energy footprint for U.S. citizens. Figure 5 shows this comparison. The data for US per capita energy footprint represents energy consumption both at work and at home. At work consumption accounts for about half of total consumption. This is shown on Figure 6 as an area of diagonal shading.

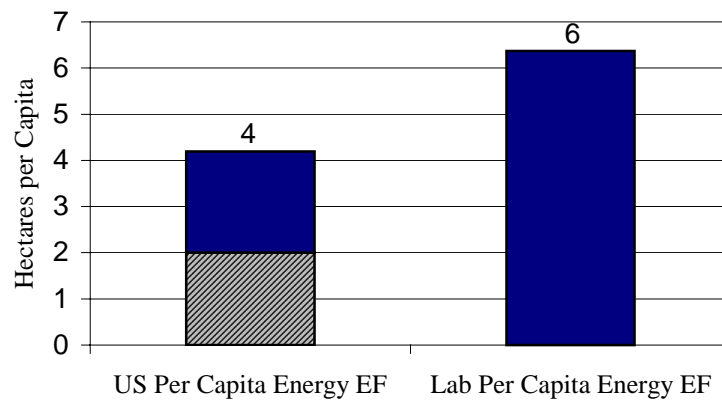


Figure 6. Comparison of Per Capita Energy Footprint of the Laboratory and the Average U.S. Citizen (work portion of US figure shown in pattern)

As can be seen by this chart, the at-work per capita energy footprint of a Laboratory employee is about three times that of the average U.S. citizen.

#### *Purchased Materials*

Another contributor to this institution's resource footprint is the land area necessary to provide the facility with purchased material input. For the purposes of this footprint analysis, contracted services were calculated as purchased materials. Actual materials are counted in the footprint in the waste category. They were not added to the purchased materials calculations to avoid double counting. In FY01, the Laboratory spent \$284.3 million on contracted services. The footprint for contracted services is determined by calculating the number of contractors and including half of their average personal footprints. The footprint for contracted services is therefore 34,000 hectares (130 square miles) for FY01. This is about 3 times the actual size of the Laboratory site.

#### *Land*

As mentioned before, the Laboratory spans an area of 43 square miles, or 11,200 hectares. A large percentage of this space has been preserved in its natural vegetative form; forests, prairie lands, and numerous streams remain intact. Approximately two and a half percent of Laboratory property has been converted to built land, in the form of buildings and roads. Although the remainder of the land is considered wild, it still serves to increase the calculations of the land footprint. Wild areas within Laboratory property are considered to be using some resources; due to human traffic and barriers the land is not truly left alone. In total, the Laboratory requires 11,700 hectares (45 square miles) of land to sustain mission activities. This difference in actual land area versus equivalent land area is due to the fact that built land uses three times the amount of land resources as does unconverted, natural land area.

## *Water*

The Laboratory is located in an area where water resources are limited. According to the State Environmental Department, water resources are being increasingly impacted by population growth, high costs of water development and treatment, groundwater mining, water pollution, drought conditions, and interstate water delivery requirements. In this stressed environment, the size of the Laboratory's water footprint can have significant effects on local communities and ecology. If the Laboratory draws too much water from the aquifer, the Rio Grande will not be able to sufficiently recharge. This can mean further threats to the habitat of the silvery minnow, an endangered species. It could also lead to a decreased water supply for downstream users of the river's water.

The source of water for the Laboratory is a series of deep wells that draws water from the Rio Grande aquifer. Under the current operation system, water is consumed for purposes such as cooling tower use, domestic use, landscaping, and temperature control. In FY01, the Laboratory used approximately 1,300 million liters (350,000 gallons) of water to sustain these activities. The footprint of water use was determined by calculating the energy required to get the water from the ground to the Laboratory. The energy was then converted into land area by calculating how much land was needed to produce that energy. The amount of energy includes all pumping, treatment, transport, and distribution of the water. The equivalent land area to accomplish these activities in FY01 was a quarter of a hectare, or about half a football field. The larger part of the total water footprint is from the actual amount of water used. This amount is calculated by assessing the water catchment area, or the area necessary to 'catch' the water. It is used in the analysis to quantify the amount of water used relative to the amount available. The equivalent land area is determined by calculating the portion of catchment area that produces the 1,300 million liters of water required by the Laboratory. It should be noted that in most footprint analyses, the water catchment area is not included. It was included in this analysis due to the serious condition of a limited water supply in New Mexico. Including the water catchment area for the Laboratory more realistically represents the institution's impact on collective resources. Water use for the Laboratory in FY01 accounts for approximately 400 hectares of equivalent land area. Therefore, the total water footprint for the Laboratory is equal to 400 hectares (1.5 square miles) for FY01.

## *Waste*

Materials are purchased from around the world, and they take the form of everything from office supplies and cafeteria food, to laboratory equipment and construction materials. The materials shipped to the site are as varied as the people requesting and using them, and more numerous. At the end of their use, materials enter the waste stream of the Laboratory. As a nuclear facility, the Laboratory has unique waste streams associated with mission activities. As mentioned above, there are six main types of waste produced by the Laboratory. These are: sanitary waste, transuranic and mixed transuranic waste (TRU and MTRU), low-level waste (LLW), mixed low-level waste (MLLW), hazardous waste, and mixed toxic substance control act waste (MTSCA).

In FY01, the Laboratory produced 8,600 metric tonnes of sanitary waste. All this material was sent either to a landfill or to a recycling center. Approximately 44% of all sanitary waste was recycled for FY01. The land area for waste was calculated by determining the embodied energy of the materials. Mathis Wackernagel, along with his collaborators in developing the footprint concept, define embodied energy as the energy used during a commodity's entire life cycle for manufacturing, transporting, using and disposing. This energy is then converted into land area. The equivalent land area necessary to reabsorb sanitary waste is equal to about 6,500 hectares (25 square miles), or 60% of the actual Laboratory site area.

TRU and MTRU waste is deposited into an underground facility located in south-central New Mexico. The facility stores the radioactive waste in disposal rooms located 2,000 feet underground in a 2,000-foot thick salt formation that has been stable for more than 200 million years. In FY01, 100 cubic meters of this type of waste were shipped to the Waste Isolation Pilot Plant facility. The footprint of TRU and MTRU waste can be calculated in two ways. In the standard way, the footprint for this waste would incorporate the embodied energy of the waste. The embodied energy of plutonium includes the energy used for mining uranium, refining uranium, radiating it in a reactor, separating the plutonium from the irradiated fuel, and recovering it and putting it into a usable form. Due to the nature of this extensive process, it is too difficult to calculate the energy required to produce the original material. All this production was done more than fifty years ago, and there is no more production of plutonium in the foreseeable future.

For this footprint analysis, the disposal of TRU and MTRU waste incorporates the energy used in transporting the waste to the facility and the area of built land taken up by the waste. The disposal of TRU and MTRU waste requires 6 hectares (0.02 square mile) of equivalent land area. Another factor to consider with this type of waste is its lifecycle. One of the largest concerns surrounding Laboratory activities is the amount of time it takes for the earth to reabsorb the radioactive waste. It takes an estimated 1 million years for Plutonium<sup>239</sup> waste to break down into a non-hazardous form. This timeline is the most critical issue in waste management at the Laboratory. However, the footprint is calculated on the timeline of one year. Therefore, the waste's lifetime of one million years does not factor into the footprint equation.

In FY01, the Laboratory produced 1200 tonnes of LLW and 15 tonnes of MTSCA waste. This waste was disposed of in landfills in Area 54. The land areas for these types of waste were calculated by using the average of the embodied energy for sanitary waste materials and by calculating the associated transportation component of delivering the waste to the landfill. The transportation component was included to account for the special nature of the waste not accounted for by the use of sanitary waste estimates. The equivalent land areas are 2,500 hectares (10 square miles) and 32 hectares (0.1 square mile), respectively.

In FY01, the Laboratory produced 290 tonnes of MLLW waste. MLLW is shipped to Salt Lake City, Utah for disposal by EnviroCare of Utah, Inc, a private waste disposal

facility. The footprint for MLLW was calculated the same way as LLW and MTSCA waste. The MLLW accounts for 670 hectares (2.5 square miles).

The Laboratory produced 26,000 tonnes of hazardous waste in FY01. This waste is separated into three separate types of waste, each shipped to a specified waste disposal facility. The hazardous waste component of the footprint was calculated by using the sanitary waste conversion factors associated with the three types of hazardous waste and calculating all three transportation factors. The combined footprint for hazardous waste accounts for 21,000 hectares (81 square miles), by far the largest part of the total waste footprint.

All together, the waste components of the footprint account for 33,000 hectares (130 square miles). This is 3 times the actual Laboratory site area.

### The Laboratory's Footprint

Overall, the Laboratory has a total ecological footprint of about 245,000 hectares (945 square miles) for FY01. The size of the Laboratory's footprint is 22 times the size of the Laboratory's actual land area. Figure 8 shows the contribution of each part of the entire Laboratory footprint in ranked order. Transportation and energy are by far the largest parts of the environmental impact from the Laboratory, followed by materials and then waste.

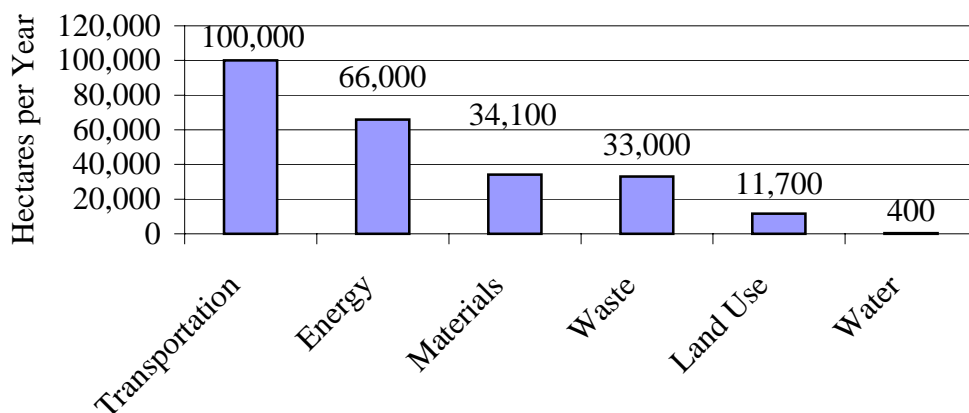


Figure 8. Laboratory's Footprint Ranked by Category for FY01

Figure 7 shows the average per capita footprint of Laboratory employees in comparison to world figures. World data is taken from the report *Ecological Footprints and Ecological Capacities of 152 Nations: The 1996 Update*. This report is from a research initiative led by Mathis Wackernagel.

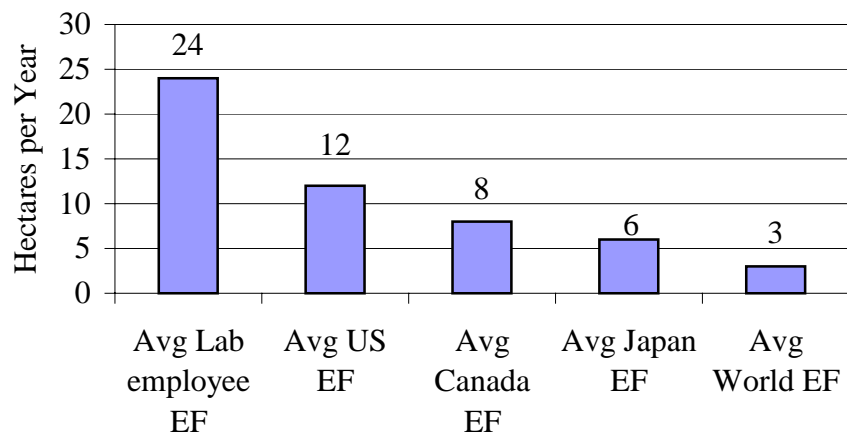


Figure 7. Per Capita Ecological Footprints of the Laboratory and World

The footprints of the countries and the world include both the industry and private resource consumption and waste production data, while Laboratory employee footprints only include industry contributions. Even so, the per capita footprint of Laboratory employees outweighs all other per capita comparison footprints. If one were to discount transportation as required by our remote location and mission related energy consumption, the Laboratory's footprint would not be substantially different from that of the average U.S. employee. One should not forget, however, that average U.S. consumption is significantly in excess of consumption elsewhere in the developed world.

### Next Steps

After all the calculations are complete, the next step is to realize the potential of this information. The environmental impact of the Laboratory is no longer an abstract notion. With the footprint, we have a normalized indicator that integrates the more common compliance measures. Each area of impact is normalized, and can be compared within the organization as well as across the industry. This ability to compare footprint results aids in prioritization of the categories of resource consumption and waste production. We can then prioritize our prevention investments, and focus on finding ways to reduce the size of the largest impacts.

Changes in the culture and policies of the Laboratory, and the mindset of employees, can lead to drastic reductions in the impact of this institution. As shown in Figure 7, the larger sources of the Laboratory's environmental impacts come from transportation, energy and materials. There are many actions the Laboratory can take to reduce the size of its transportation footprint. One approach is to reduce the impact of the largest component of transportation, inbound freight. Currently, the Laboratory purchases 50% of materials from across the country and overseas. By increasing locally produced and distributed materials and services, the Laboratory can decrease a major source of the transportation footprint. The second largest component of transportation is employees

commuting to work. This can be reduced by reestablishing a regional bus system, promoting and facilitating ride sharing, supporting telecommuting, and/or investigating the potential for satellite offices. The impacts of on-site travel can be reduced by increasing on-site video conferencing, purchasing alternative fuel and fuel-efficient government vehicles, and increasing the safety and coverage of bicycle paths to promote alternative travel methods. To reduce the impact of air travel, the third largest part of transportation, the Laboratory can promote video conferencing or it can purchase green tags.

Green tags are additional energy purchases designed to offset the climate change and other environmental impacts of your energy use. One green tag represents the environmental attributes associated with a certain number of megawatt-hours of renewable electricity. Green tags can be purchased to offset the production of CO<sub>2</sub> from air travel. They can also be used to offset other Laboratory energy uses.

Half of the energy component of the Laboratory's footprint is comprised of electricity use. Laboratory electricity use over the past year has decreased. However, this trend can be associated with an unusually warm winter in FY2001 and the fact that LANSCE operated half as much in FY2001 as in FY2000. Peak electrical demand is greatest when LANSCE is operating. The decrease in electrical use is therefore not due to implementing sustainable practices; it was a chance occurrence that did not involve an increase in efficiency. With the addition of new facilities and research initiatives and with the regional and national electrical utilities operating near capacity, there is a need for precise management and increased conservation efforts. Supporting energy conservation projects and pursuing renewable energy sources can help to reduce energy use. In the current arrangement with power supply companies, it would be extremely difficult to switch to a company providing renewable energy. However, the Laboratory can use renewable energy by producing its own on site, in the form of photovoltaic cells and fuel cells. Another important practice is to ensure that energy conservation is incorporated into all new construction projects. The Laboratory is currently investigating the possibility of using Leadership in Energy & Environmental Design (LEED<sup>TM</sup>) criteria for new construction projects. LEED<sup>TM</sup> is a tool, developed by the U.S. Green Building Council, to help design teams and owners incorporate sustainability and resource conservation into building design efforts.

Although ranked fourth, waste production at the Laboratory is a large concern due to its special nature. One way to reduce this impact is to increase recycling and waste reduction education initiatives, incorporating them into the basic employee training and refresher courses. A large part of reducing the impact of waste production will be from preventing its generation; technological advances and materials conservation are key to reducing waste streams. For sanitary waste reduction, efforts can be made to reduce the embodied energy of the materials. Contracts can be pursued with specifications for an increase in the amount of recycled content requirements, reductions in packaging, and the ability to return materials for recycling at the end of the lifecycle.

In the end, it can be argued that some of the methodology of this footprint tool is based on estimates and suppositions. Although calculations were performed as conservatively as possible, the size of the environmental impact may indeed be inaccurate. However, the ecological footprint is so far the best estimate of the integrated environmental impact possible. (In any case, if this methodology is used to compare Laboratory energy consumption over time any inaccuracies cancel themselves out.) By calculating the Laboratory's footprint, we see that it is inarguable that the Laboratory is having a disproportionate effect on our environment. Some of these effects are beyond our control; the location and mission of the Laboratory make it difficult to tread lightly on the earth. The footprint is designed to show us where we can make changes. It can lead us towards the right qualitative decisions in our business practices. Finally, we are given the opportunity to consider altering the ways we do business, in essence altering the fabric of our institution, in order to reduce our impact to the environment.

## Appendix A

Calculations Table showing Laboratory consumption, conversion factors, and information sources for the Ecological Footprint calculations.

Component	Lab Consumption	Unit	Source	Conversion Factors	Unit	Source	FOOTPRINT (ha yrs)
<b><u>ENERGY</u></b>							
Natural gas (for heating)	1228844	Decatherms	Mark Hinrichs <sup>1</sup>	0.0132	ha yrs/ Decatherm	SNI Book <sup>2</sup> p.83	16,220.74
Natural gas (for electricity)	11.817	GWH	Mark Hinrichs	94	ha yrs/gWh	SNI Book p.83	1,110.80
Coal	244.9309	GWH	Mark Hinrichs	161	ha yrs/gWh	SNI Book p.83	39,433.87
Hydroelectric	118.3951	GWH	Mark Hinrichs	75	ha yrs/gWh	SNI Book p.83	8,879.63
<b>TOTAL ENERGY</b>							<b>65,645.05</b>
<b>TOTAL PER CAPITA</b>							<b>6.37</b>
<b><u>WATER</u></b>							
Water consumption	1318.56	mill L	John Arrowsmith <sup>3</sup>				
CO <sub>2</sub> produced	1,458,142.27	kg	NEF <sup>4</sup>				
CO <sub>2</sub> produced/ mill L water	1,105.86	kg		0.0002223	ha yrs/kg	SNI Book p.99	0.25
Water catchment area	0.30	ha yr/mill L	USGS, NMSU <sup>5</sup>	1318.56	mill L	SNI Book p.100	395.85
<b>TOTAL WATER</b>							<b>396.10</b>
<b>TOTAL PER CAPITA</b>							<b>0.04</b>
<b><u>TRANSPORTATION</u></b>							
Freight transport (inbound)	675,839.55	1000t-km	Bob Travis <sup>6</sup> **	0.07road, 0.32 air	ha yrs/1000 tonne-km	SNI Book p.87	75,121.10
Freight transport (outbound)	1,878.43	1000t-km	Bob Travis	0.07road, 0.32 air	ha yrs/1000 tonne-km	SNI Book p.87	413.25
Commuting on site	37,094.40	1000 pass-km	Marla Maltin <sup>7</sup>	0.93	ha yrs/1000 passenger km	SNI Book p.85	3,876.79
Commuting to the site	117,632.49	1000 pass-km	John Pantano <sup>8</sup> **	0.83	ha yrs/1000 passenger km	SNI Book p.85	12,169.86
Air	131,247.97	1000 pass-km	Guy Sandusky <sup>9</sup> **	0.07	ha yrs/1000 passenger km	SNI Book p.86	9,187.36
<b>TOTAL TRANSPORTATION</b>							<b>100,768.36</b>
<b>TOTAL PER CAPITA</b>							<b>9.78</b>
<b><u>LAND USE</u></b>							
Built-up area	270.62	hectares	Winters Redstar <sup>10</sup> **	2.83	yrs	SNI Book p.73	765.86
Wild area	10,981.9	hectares	Winters Redstar				10,981.9

<b>TOTAL LAND USE</b>							<b>11,747.76</b>
<b>TOTAL PER CAPITA</b>							<b>1.14</b>
<b><u>PURCHASED MATERIALS</u></b>							
Services	284,300.00	1000 dollars	Amy Curtis <sup>11</sup>	0.12	ha-yrs/ 1000 dollars	Marla Maltin	34,116
<b>TOTAL MATERIALS</b>							<b>34,116.00</b>
<b>TOTAL PER CAPITA</b>							<b>3.31</b>
<b><u>OUTPUT WASTE</u></b>							
TRU/MTRU	107.61	m <sup>3</sup>	Pat Gallagher <sup>12</sup>	0.05	ha yrs/m <sup>3</sup>	Marla Maltin, Bryan Carlson <sup>13</sup>	5.89
LLW	1174.95	m <sup>3</sup>	Pat Gallagher	2.2	ha yrs/m <sup>3</sup>	MM, BC	2,586.74
MLLW	291.6	m <sup>3</sup>	Pat Gallagher	2.31	ha yrs/m <sup>3</sup>	MM, BC	674.36
Hazardous	26250	tonne	Pat Gallagher	0.81	ha yrs/tonne	MM, BC	21,317.3
MTSCA	14.78	m <sup>3</sup>	Pat Gallagher	2.2	ha yrs/m <sup>3</sup>	MM, BC	32.54
<b><u>Sanitary</u></b>							
landfill							
paper	560	tonnes	Pat Gallagher	3	ha yrs/tonne	SNI Book p. 95	1680
glass	80	tonnes	Pat Gallagher	1	ha yrs/tonne	SNI Book p.95	80
plastic	210	tonnes	Pat Gallagher	3.6	ha yrs/tonne	SNI Book p.95	756
aluminum cans	26	tonnes	Pat Gallagher	9.4	ha yrs/tonne	SNI Book p.95	244.4
wood	100	tonnes	Pat Gallagher	0.995	ha yrs/tonne	SEI/ Dr. Barrett <sup>14</sup>	99.5
cardboard	250	tonnes	Pat Gallagher	1.327	ha yrs/tonne	SEI/ Dr. Barrett	331.75
food	650	tonnes	Pat Gallagher	0.498	ha yrs/tonne	SEI/ Dr. Barrett	323.7
other	90	tonnes	Pat Gallagher	0.846	ha yrs/tonne	SEI/ Dr. Barrett	76.14
clean fill (dirt and concrete)	2363	tonnes	Pat Gallagher	0.564	ha yrs/tonne	SEI/ Dr. Barrett	1332.732
other construction debris	453	tonnes	Pat Gallagher	0.995	ha yrs/tonne	SEI/ Dr. Barrett	450.735
recycled							
paper	644.8	tonnes	Pat Gallagher	2	ha yrs/tonne	SNI Book p.95	1289.6
metal	845.66	tonnes	Pat Gallagher	0.4	ha yrs/tonne	SNI Book p.95	338.264
tires	12.44	tonnes	Pat Gallagher	1.5	ha yrs/tonne	Marla Maltin	18.66
cardboard	319.13	tonnes	Pat Gallagher	2	ha yrs/tonne	SNI Book p.95	638.26
brush	99.53	tonnes	Pat Gallagher	0.5	ha yrs/tonne	Estimate from SEI/ Dr. Barrett	49.765
concrete	730	tonnes	Pat Gallagher	0.5	ha yrs/tonne	Marla Maltin	365
dirt	1151	tonnes	Pat Gallagher	0.52	ha yrs/tonne	Marla Maltin	602.81
<b>TOTAL WASTE</b>							<b>33,294.15</b>
<b>TOTAL PER CAPITA</b>							<b>3.23</b>
<b>TOTAL FOOTPRINT</b>							<b>245,967</b>
<b>TOTAL PER CAPITA</b>							<b>23.87</b>

\*\* Indicates that Laboratory consumption data was extrapolated from information provided by listed source

## Appendix B

### References

#### *From Calculations Table of Appendix A:*

1. Mark Hinrichs, Los Alamos National Laboratory, FWO-UI
2. Chambers, et al. Sharing Nature's Interest: Ecological Footprints as an Indicator of Sustainability. Earthscan Publications Ltd, London and Sterling, VA. 2000
3. John Arrowsmith, Department of Public Utilities, County of Los Alamos
4. National Energy Foundation: [www.natenergy.org.uk/convert.htm#calc](http://www.natenergy.org.uk/convert.htm#calc)
5. US Geological Survey Atlas, New Mexico State University weather data
6. Bob Travis, Los Alamos National Laboratory, BUS-4
7. Marla Malin, Los Alamos National Laboratory, ESO
8. John Pantano, Los Alamos National Laboratory, HR-WDA
9. Guy Sandusky, Los Alamos National Laboratory, BUS-1
10. Winters Redstar, Los Alamos National Laboratory, ESH-20
11. Amy Curtis, Los Alamos National Laboratory, BUS-2
12. Pat Gallagher, Los Alamos National Laboratory, ESO
13. Bryan Carlson, Los Alamos National Laboratory, ESO
14. SEI Footprint Approach, Stockholm Environment Institute, Dr. John Barrett

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